N71-23942

NASA SP-5905 (02)

TECHNOLOGY UTILIZATION

SEALS AND SEALING TECHNIQUES

A COMPILATION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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TECHNOLOGY UTILIZATION OFFICE 1970
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C.

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Foreword

The National Aeronautics and Space Administration and the Atomic Energy Commission have established a Technology Utilization Program for the dissemination of information on technological developments which have potential utility outside the aerospace community. By encouraging multiple application of the results of research and development, NASA and AEC earn for the public an increased return on the investment in aerospace research and development programs.

This publication is part of a series intended to provide such technical information on a group of selected seals and sealing techniques. The items, which are presented in summary form, may be of particular interest to a variety of industries in solving sealing problems. These innovations are believed to be both useful and practical.

Additional technical information on individual devices and techniques can be requested by circling the appropriate number on the Reader's Service Card included in this compilation.

Unless otherwise stated, NASA and AEC contemplate no patent action on the technology described.

We appreciate comment by readers and welcome hearing about the relevance and utility of the information in this compilation.

Ronald J. Philips, *Director*
Technology Utilization Office
National Aeronautics and Space Administration

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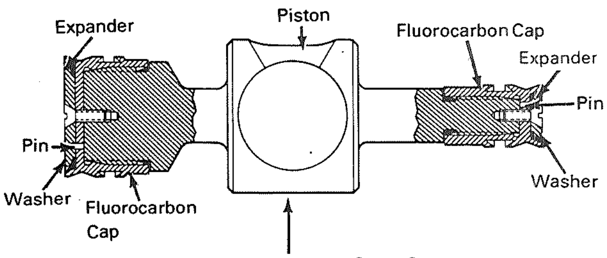
Section 1. Seals and Gaskets

FLUOROCARBON SEAL REPLACES METAL PISTON RING IN LOW-DENSITY-GAS ENVIRONMENT

The compression of low-density gases requires a closely conforming piston-cylinder configuration. The metal piston rings, however, allow excessive leakage through the ring gaps as well as leakage at bottom dead center when the piston ring moves from one side of its groove to the other. To solve this problem, a reinforced fluorocarbon seal that eliminates the need for rings and provides an integral lip-type seal was developed. The sealing lip is sufficiently flexible to conform to the cylinder during changing conditions, and no high friction loss is encountered when a ring is sufficiently spring loaded with an expander ring to prevent it from sticking in its groove. The fluorocarbon seal may be useful as cryogenic compressor piston seals, especially compressors for H_2 and He.

A thread is machined on the ends of the undersized stainless steel piston, and oversized fluorocarbon caps are screwed onto the piston and bonded in place with epoxy. The seal is then machined to the configuration shown in the figure. A thin flexible lip on the leading edge of the piston forms a seal with the cylinder. During the low pressure portion of the compression cycle, a stainless steel serrated disk spring is used to preload the lip for better sealing.

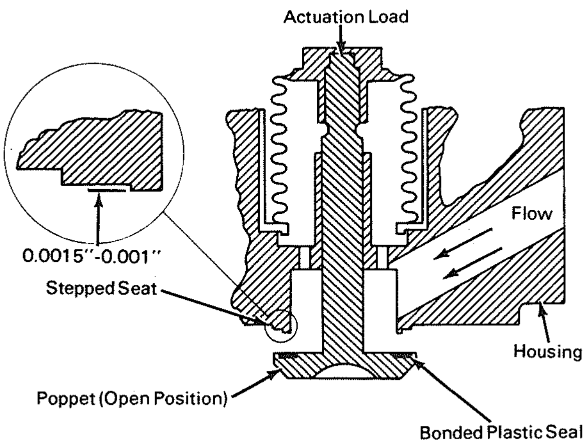


Opposed Piston for Two-Stage Compressor (Used with Oscillating Drive Mechanism)

Source: W. D. Morath and N. E. Morgan of Vickers, Inc.
under contract to
Lewis Research Center
(LEW-10277)

Circle 1 on Reader's Service Card.

DOUBLE-AREA SEAT FOR PLASTIC SEALS



A double-area seat configuration, in which a primary sealing surface has been added (i.e., a small contact area at low pressure, and a large contact area at high pressure), has been developed. This innovation provides an adequate sealing force at low as well as high pressures, without permanent deformation of the plastic seal. A typical poppet valve for use in rocket engines is shown in the figure. The valve is normally closed, and is required to maintain a seal at the poppet seat under low pressure and installed-spring (bellows) load. For fail-safe purposes the valve is pressure biased to the close position, while at shutdown under high pressure the high load is sensed at the poppet seat. Potential industrial uses of this innovation, which can be easily manufactured and repaired, include vent valves, relief valves, a variety of check valves, and chemical applications.

A blown up view of the seat area is illustrated in the figure . The "raised" step is so designed that when supporting the lowest load at which a seal is required, the unit load will be adequate. As the propellant pressure in the valve is increased, the plastic poppet seat deforms by the height of the step until it is supported by the full seat area. This keeps the stresses on the plastic below the yield strength at maximum propellant pressure. Although a permanent deformation occurs at the raised step, it is not as deep as the height of the step.

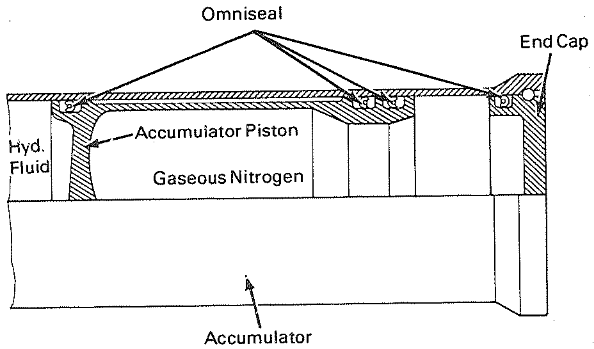
Source: A. P. Swift, Jr. of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-14124)

Circle 2 on Reader's Service Card.

OMNISEAL FOR LOW-TEMPERATURE APPLICATIONS

A novel seal has been developed that may be useful at low temperatures, under both static and dynamic conditions. This innovation was initially designed as an omniseal for an accumulator; it is self-pressurizing and would be useful in most hydraulic and pneumatic applications, particularly where a fit is loose or where flexure is significant.

The omniseal is constructed of a plastic (Teflon) case in the form of a ring similar to an O-ring and a flat ribbon double coil spring. The spring exerts pressure against the sides of the case, providing an initial sealing load when the seal is unpressurized. The spring also compensates for dimensional changes resulting from tolerance variations, thermal expansion or contraction, and cold flow of the plastic. The seal is so designed that when properly oriented to the applied pressure, it activates and makes a positive seal.



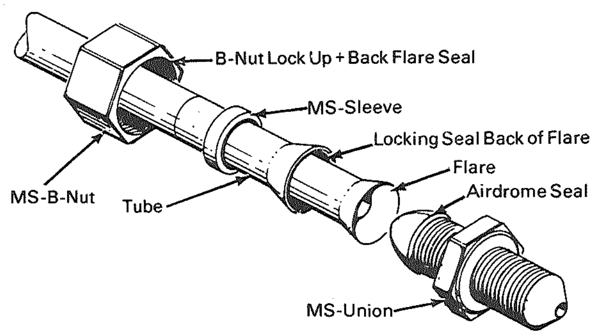
Source: Robert E. Davenport of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-16449)

Circle 3 on Reader's Service Card.

SEAL LOCK

A seal of potential industrial use is shown in the figure. This innovation, known as the "seal lock," can be used on aircraft to provide a positive seal, especially under conditions of vibration. In tests, it gave a positive seal on both sides of flared tubes up to 10,000 psig, and eliminated the need of lubricants to ease torque application.

The seal lock can be made of either copper, aluminum, nylon, polytetrafluoroethylene, or steel approximately 0.009-in. thick, with or without a

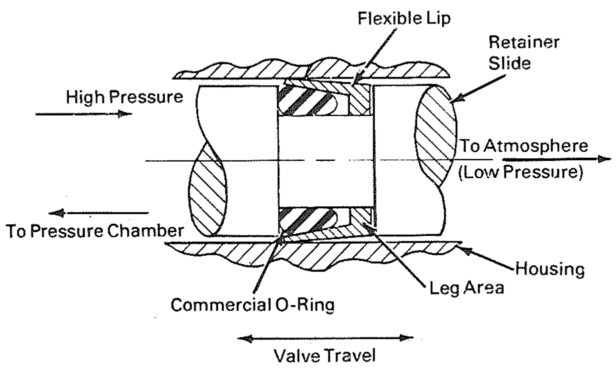


split-ring arrangement. To achieve a seal, the unit is placed over the tube before or after the flaring process and pushed down the tube until contact is made to the back of the flare. The B-nut and sleeve are then positioned against the seal and locked to the union.

Source: B. T. Howland of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-16250)

Circle 4 on Reader's Service Card.

RETAINER FOR SLIDE-VALVE SEAL



A slide valve consisting of a standard O-ring inside the groove of a shaft and protected by an "L" shaped (in cross section) retainer that supports and protects the O-ring has been designed. The slide valve seal, which has maintained a positive seal up to 5000 psi during operations, could be used in either a hydraulic or pneumatic system. It would be particularly applicable in industrial operations requiring a slide control valve with near zero leakage, rapid pressurization and venting, minimum friction, and where small orifices come in contact with the seal.

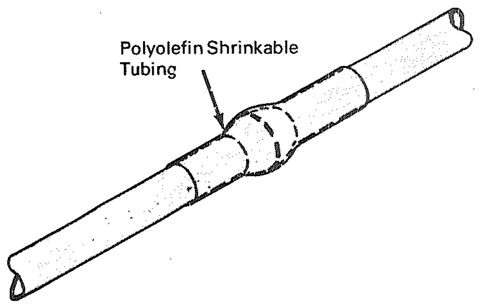
The use of an "L" shaped retainer that allows the O-ring to deform under pressure while supporting and protecting it from extruding out of the gland has been used in a counterbalance assembly control valve. The skirt of the retainer protects the O-ring from being damaged while passing over an orifice 0.001 in. in diameter; the vertical leg provides good stability and support. A polytetrafluoroethylene material impregnated with graphite has a low coefficient of friction and is stronger than other materials that were tested. A sketch of the slide valve under pressurization (exaggerated) is shown in the figure.

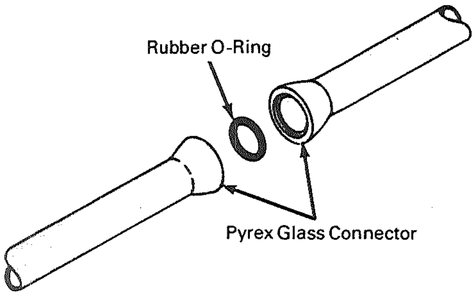
Source: Joseph C. Wilkowski
and Paul K. Miller, II of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15311)

No further documentation is available.

HEAT-SHRINK PLASTIC TUBING FOR SEALING JOINTS IN GLASS TUBING

A lubricant-free seal for joints in a glass vacuum (or pressure) system has been developed. Small units of standard glass apparatus are held together by short lengths of transparent heat-shrinkable polyolefin tubing, which is shrunk over glass O-ring type connectors having O-rings but no lubricant. Hot air from a standard heat gun is directed at the joint from all directions until the tubing shrinks about the joint. The tubing is then allowed





to cool. This sealing operation can be performed in a short period of time, and the polyolefin tubing can be easily removed for disassembly and cleaning by heating it again to a higher temperature.

In tests of this seal, joint connections remained vacuum tight to a vacuum of 10^{-5}mm of mercury for about two months, and they worked well at a positive pressure of half an atmosphere. A connector based on this principle was also used to connect a water distillation flask to a condenser, without softening under the heat load; it proved serviceable at even higher temperatures by directing a jet of cooling air at the plastic tubing.

Source: Betty Del Duca and
Arthur Downey
Lewis Research Center
(LEW-10329)

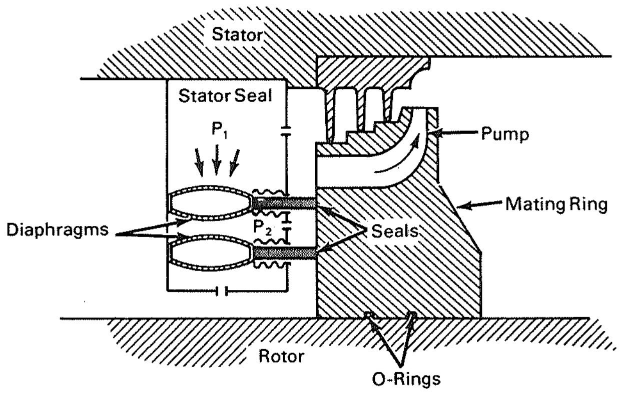
No further documentation is available.

CRYOGENIC SEAL CONCEPT FOR STATIC AND DYNAMIC CONDITIONS

A seal assembly concept has been developed that could reduce leakage in a cryogenic pump under both static and dynamic conditions. The assembly consists of a stator-seal housing with primary and secondary seal rings fitted into annular diaphragms and preloaded against a rotor-mounted mating ring. This concept is applicable to any rotating machinery where pressure-actuated sealing under cryogenic conditions is useful.

The seal ring bearing load is increased during static conditions by the static pressure P_1 (see fig.) and the temperature of the cryogen. The static pressure P_1 bearing on the diaphragms and the cryogenic temperature, which lowered the diaphragm pressure, causes inward deflection on the stator-seal diaphragms, bringing about an increased bearing force for better sealing.

A secondary stator seal creates a cavity to trap any leakage past the primary one. Any increase in pressure P_2 in the cavity between the diaphragms caused by leakage will result in increased bearing loads to both stator seals. Under dynamic conditions, the stator-seal bearing loads must be reduced to prevent overheating and excessive wear.



This is accomplished by a small pump (built into the rotor-mating ring) to lower the stator-seal pressure and relieve the stator-seal bearing loads as the pump operates.

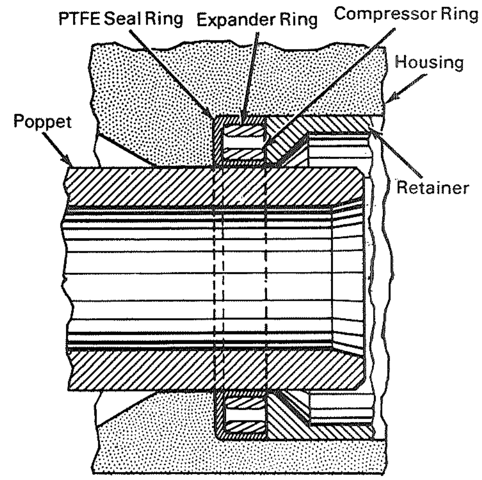
Source: E. A. DeGaetano of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-12986)

Circle 5 on Reader's Service Card.

DYNAMIC VALVE SEAL FOR USE AT CRYOGENIC TEMPERATURES

Another cryogenic seal for general industrial application has been developed. This C-shaped polytetrafluoroethylene (PTFE) seal ring, interference-fitted internally with a metal expander ring and a metal compressor ring, is shown in the figure. It will provide a reliable seal in cryogenic fluids over a fluid pressure range of 0 to 2000 psig.

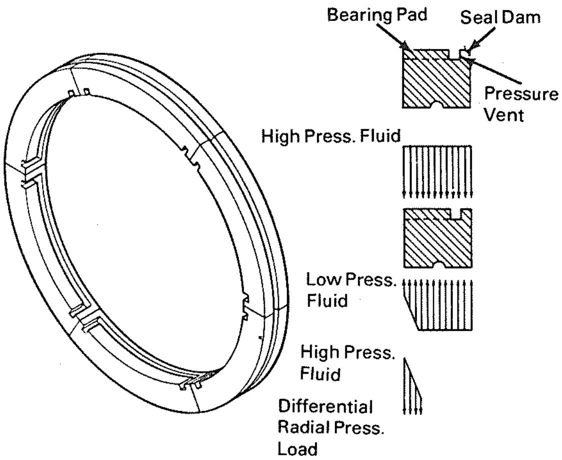
In this dynamic valve seal, the PTFE ring is dimensioned to obtain an interference fit on the outside diameter (in contact with the housing), thus minimizing the stress in the PTFE at cryogenic temperatures. The metal expander ring in contact with the outer leg of the PTFE ring has a much lower coefficient of thermal expansion than the mating housing, thus ensuring proper sealing at lower temperatures. Both the metal expander and the compressor rings are dimensioned to obtain interference fits. The sealing surfaces of the PTFE seal ring (the upper and lower legs) are serrated. The ridges of the serrations flow into the depressions when interference occurs on assembly. The assembly is accomplished by cooling the subassembly of the PTFE ring and the two metal rings in liquid nitrogen, dropping in place, warming to ambient temperature, and then assembling the poppet in a similar manner.



Source: H. E. Moxley of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-12987)

Circle 6 on Reader's Service Card.

SEGMENTED, ARCH-BOUND CARBON SEAL



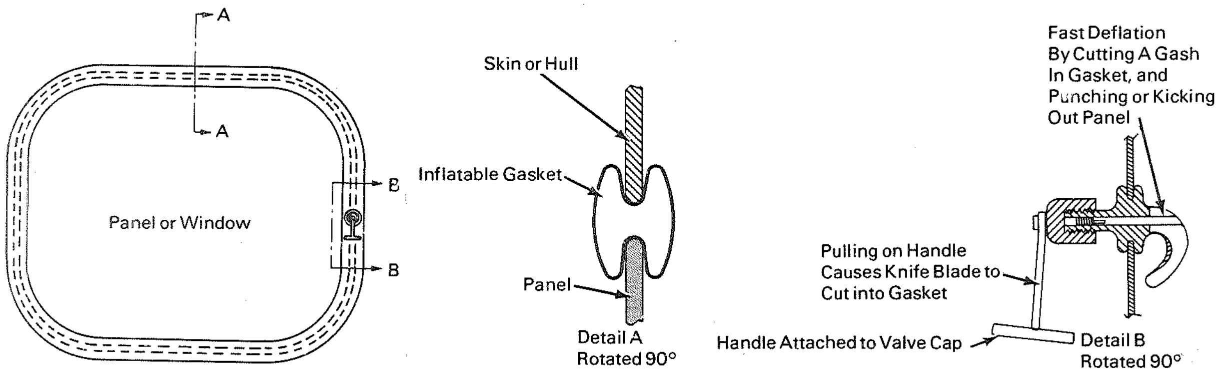
A positive seal with a low leakage rate and minimum loading requirements has been developed for a high-pressure, large-diameter fluid-impeller shaft with large axial and radial movements.

An impeller seal with a leakage rate 1/30th of conventional metal labyrinth seals and 1/10th of close-clearance plastic seals can be obtained by modifying a conventional segmented carbon seal. The modification causes the segments to become arch-bound at a diameter slightly larger than the outside diameter of the rotating shaft so that a portion of the load is carried in hoop stress.

Source: R. E. Burcham of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-12777)

No further documentation is available.

SEAL FOR EMERGENCY ESCAPE WINDOW



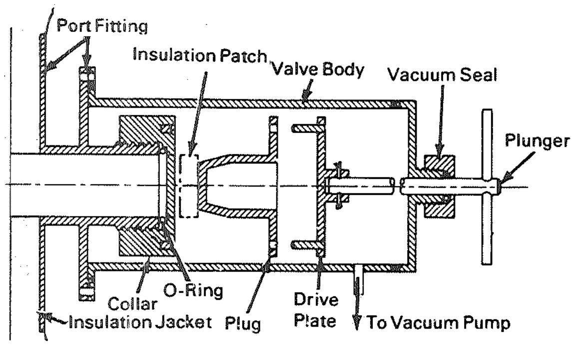
A device for sealing a window or panel is schematically illustrated in the figure. It allows the rapid and easy removal of a window for emergency escape. This seal should be of particular interest to industries that design or build tanks, submarines, chemical plants, ships, and underwater equipment in which fast escape from enclosures is a critical factor.

An inflatable type molding or gasket is placed around the window so that it can be easily deflated with a built-in knife, allowing the window to be pushed or kicked out with a minimum of force.

Source: Saul Davidson of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-12914)

No further documentation is available.

HAND-OPERATED PLUG INSERTION VALVE



A lightweight hand-operated plug insertion valve (weighing 1/7th as much as a conventional vacuum valve) has been developed to seal upper-stage liquid hydrogen tanks on the launching pad. A port fitting is bonded to the insulation jacket during fabrication of the upper-stage tank. The valve body collar is assembled to the port fitting, and it has an internal O-ring. A vacuum source evacuates the insulation jacket to the desired pressure level and the port is sealed by pushing on the valve plunger. The drive plate pins engage holes in the plug and, through the plug flange, holes in the collar. When the plunger is twisted, it tightens the plug-to-collar interface, thus compressing the O-ring to make a vacuum-tight connection. The drive plate is then withdrawn and the valve body with associated vacuum plumbing is removed from the port fitting of the insulation jacket.

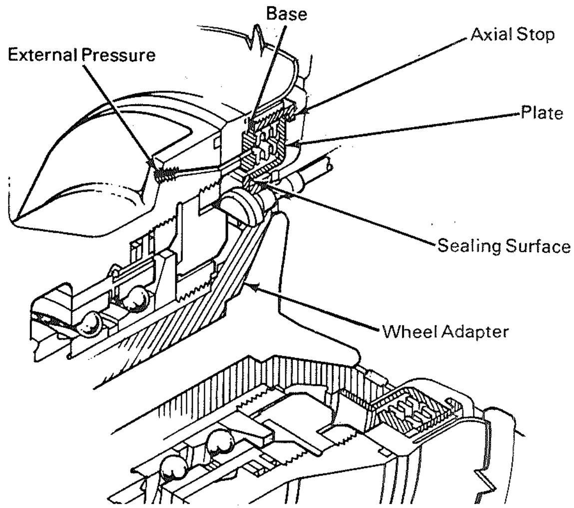
Source: Robert G. Jones
Marshall Space Flight Center
and James A. Roney of
Hayes International Corp.
under contract to
Marshall Space Flight Center
(MFS-12019)

Circle 7 on Reader's Service Card.

A SEAL FOR REDUCING HYDROGEN LEAKAGE UNDER STATIC CONDITIONS

A pressure-actuated seal has been developed that will reduce the leakage of hydrogen through the turbopump shaft of the J-2 engine during standby and allow a gap between the seal and rotating wheel adapter during dynamic operations. This innovation may be of interest to those industries that design or build engines in which hydrogen is used.

The seal, consisting of a base and a plate with two sets of bellows welded between them, is installed in series with a relatively low-surface-speed shaft seal. Cylindrical sealing surfaces are provided on the seal plate and turbine-wheel adapter. The seal bellows in tension forces the sealing surfaces to remain in contact statically. Pressure from an external source extends the bellows prior to start, creating a gap between the seal and the rotating wheel adapter during dynamic operations. Thus, the seal can limit leakage at static conditions by positive contact of the sealing surfaces and prevent damage during dynamic conditions by forming a gap between the rotating member and the seal.



Source: V. Macys of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-14567)

Circle 8 on Reader's Service Card.

Section 2. Sealing Techniques

TECHNIQUE TO IMPROVE ACTUATOR PISTON SEAL

A reliable means of supporting actuator piston-lip seals and providing a guide to control radial piston movement has been developed. This was accomplished by an arrangement of double-mounted lip-type plastic seals, fabricated from thin sheets of mylar, and separated by a spacer ring to allow proper functioning. The innovation was based on the design configuration proposed for the main propellant valve actuator piston seal of the J-2 engine. This technique may be applicable to other actuator piston seals using thin (0.005 to 0.015-in. thick) mylar lip seals, where radial loads developed by a mechanical linkage must be accommodated.

The sealing lips face in opposite directions, and a polytetrafluoroethylene backup ring is mounted around the piston between the dual lips. The backup ring maintains an ideal seal-lip contour, thus preventing pressure and friction from distorting the seal during dynamic operation. In addition, the backup ring maintains seal-contact pressure at the lips to provide a better seal and minimize wear by reducing the entrance of contaminants.

Source: T. W. Rose of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-14125)

Circle 9 on Reader's Service Card.

COMBINATION STATIC SEAL AND THREAD LOCK FOR EXTREME TEMPERATURE APPLICATIONS

A combination static seal and thread lock has been developed that is not affected by either high or low temperature extremes. The novel feature of this technique is the use of metal putty for both a seal and thread lock. It could be useful in such industrial applications as (1) low-cost household plumbing connections, (2) permanent underground and underwater pipe line connections, (3) outdoor plumbing in severe climates, and (4) oil refinery plumbing.

Conventional seals are made with either elastomeric compounds, plastics, felts, cork, soft copper, or machined steel "lips." All of these materials except the metallic ones lose their resilience at low temperatures, and even the metallic seals need a highly polished surface to bear against. The technique proposed here, however, provides a low-cost seal for all temperatures; it does not require a polished surface.

The conventional insert-type lock, which is ineffective after being used once, is sometimes used again either inadvertently or to reduce costs. Other conventional locks also have shortcomings. On the other hand, this new locking technique has virtually unlimited life and cannot be broken accidently.

Source: Robert L. Ammerman of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15183)

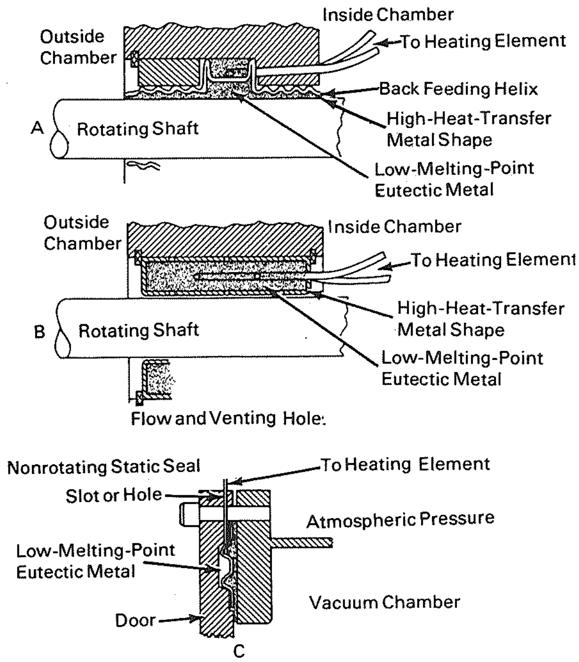
No further documentation is available.

VACUUM SEALING UNDER BOTH DYNAMIC AND STATIC CONDITIONS

A technique has been developed for vacuum sealing a rotating shaft with a eutectic metal without wear and deterioration of the seal. During rotation, an electric heating element melts the metal, providing a liquid seal on the shaft; when the shaft is irrotational, the metal forms a solid seal.

In the figure (A) a liquid metal seal is made between the rotating shaft and the back-feeding helix when electric current is passed through the heating element. The back-feeding helix tends to contain the liquid metal under its area. The helix metal (e.g., aluminum tubing) is fabricated to provide good thermal transfer and good vacuum sealing properties. Sufficient area under the back-feeding helix is designed into the bearing to withstand the pressure differential from the outside chamber to the vacuum (inside) chamber. The low-melting-point eutectic metal contains gallium, thus assuring that the liquid metal will wet a slowly rotating shaft.

In the figure (B) a bearing configuration is shown in which the low-melting-point eutectic metal is used. This configuration, wherein the metal was contained in a journal-type bearing, does not fit tightly on the rotating shaft but allows a slight gap. Thus, when the metal is heated, it becomes a



liquid and flows out through the apertures wetting the rotating shaft. The hole in the inner and outer diameter provides flow and venting for the liquid metal.

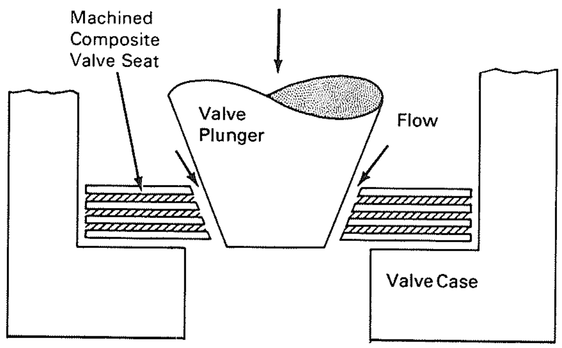
In the figure (C) a static application of the principle is shown. A metal seal is placed in the door of the chamber and, when electric current is passed through the heating element, the metal becomes liquid. A continuous seal formed around the door, together with a similarly shaped metal area embedded in the wall of the chamber facing the door, provides the sealing interface between the door and the chamber.

Source: R. E. Imus
NASA Pasadena Office
(XNP-09751)

Circle 10 on Reader's Service Card.

LAMINATING TECHNIQUE FOR FABRICATING COMPOSITES AT CRYOGENIC TEMPERATURES

Plastic materials used for valve seats and seals perform several vital functions, but the primary one is to absorb the dimensional mismatch between mating metal faces of the valve plunger and seat to prevent gas or liquid leakage. The plastic seat must be sufficiently resilient to maintain intimate contact between the metal faces and must resist compression set (cold-flow) while the valve is in storage.



Although either rubber or elastomeric materials can normally satisfy these requirements, fluorocarbon plastics are needed if the valve is to be used at cryogenic temperatures. Even at −423° F, fluorocarbon plastics are marginal in resiliency and dimensional stability, resulting in leakage and malfunction of the valve. A group of polyimide plastics was found to have outstanding dimensional stability at cryogenic temperatures, and in film form (less than 5 mils thick) was resilient over a far greater range than the fluorocarbon plastics. Since most valve-seat and seal designs require plastics thicker than 5 mils, a laminating technique was developed to form a composite capable of molded contour retention and thickness variation. This was brought about by bonding 5-mil-thick layers of polyimide film with void-free polyurethane adhesive (less than 0.25-mil thick) cured at 160°F under a pressure of 100 psi. The surfaces of the polyimide film were prepared for bonding by wiping on a solution of methyl alcohol and hydrochloric acid.

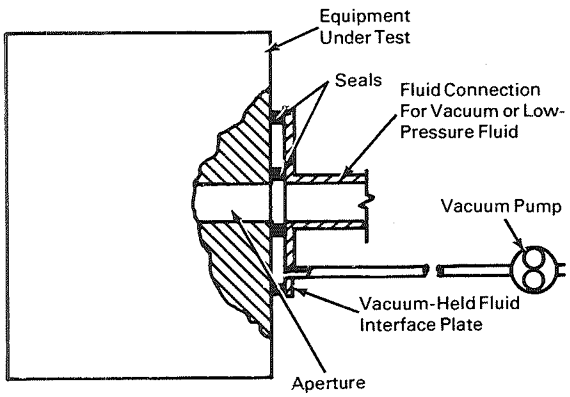
Other laminated combinations have also been fabricated to achieve specific properties, including: (1) polytetrafluoroethylene-surfaced polyimide on the outer plies to reduce the surface coefficient of friction; (2) glass fiber reinforcement in the polyurethane adhesive layer to increase the tensile strength; and (3) nylon and a specific fiber reinforcement in the polyurethane adhesive to achieve greater tear resistance.

Source: Carl R. Lemons of
McDonnell Douglas Corp.
under contract to
Marshall Space Flight Center
(MFS-14938)

Circle 11 on Reader's Service Card.

VACUUM-HELD FLUID INTERFACE PLATE

This technique is based on the principle that a vacuum-held plate can create a sealed fluid interface with an existing aperture, when normal connectors are not provided. Since the plate is not required to be inserted into the aperture, it does not restrict flow as in previous techniques. Formerly an expandable device was inserted into the aperture and enlarged to create a seal. Under conditions where flow restriction was critical, the expandable type insert was not suitable.



The vacuum-held fluid interface plate can be used in commerce and industry to make temporary fluid connections for testing (e.g., flow measurement and press operations) where provision for normal connectors has not been made.

Source: L. Samuelson of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-11483)

No further documentation is available.

CRYOGENIC SEALING WITH ELECTRICAL WIRE

Another sealing technique for cryogenic applications has been devised in which a stranded electrical wire coated with Teflon is used to seal two irregular surfaces. One of the surfaces to be sealed serves as the lay-up and template surface. The coated wire is laid in a two-ring spiral around the periphery of one of the flange surfaces to be sealed, and Teflon tape is placed around the wire at various locations to maintain the desired seal size. A continuous layer of the tape is placed over the wire, securing it to the sealing surface. The two surfaces are then mated and the bolts tightened.

This technique should be of particular interest to industrial and research facilities that require a quick, inexpensive cryogenic seal for flat or irregular flange surfaces.

Source: Robert J. Stewart of
McDonnell Douglas Corp.
under contract to
Marshall Space Flight Center
(MFS-12245)

Circle 12 on Reader's Service Card.

SEALING OBSERVATION PORTS WITH A HIGH-PRESSURE ADHESIVE COMPOUND

Quartz, sapphire, and other optical materials suitable for viewing ports in high-temperature, high-pressure chambers frequently encounter failure or degradation caused by loads induced by deflections under pressure. When sufficient clearance is provided to accommodate these deflections, the ports tend to leak at low pressure. A high-temperature adhesive compound (RTV-602) can be used as a gasket to close the necessary clearance at low pressure and provide a resilient faying surface for even load distribution at high pressure.

The sealing of the mating transparent sheets of optical materials is accomplished with vulcanizing silicone rubbers that can be catalytically activated at room temperature. It is necessary to mechanically constrain the transparent section at its four edges and at each end to prevent leaking and damage to the photographic equipment.

This technique could be used advantageously in laboratory and high-temperature processing operations. It may also be beneficial in industrial operations involving large-area observation ports in vacuum-processing rooms and environmental chambers in which the use of glass is not feasible.

Source: W. M. Ford of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-18029)

Circle 13 on Reader's Service Card.

TECHNIQUE FOR FORMING SILICONE RUBBER SEALS

Although silicone rubber compounds cured by atmospheric humidity can be used for sealing, they usually must be worked to smooth out irregularities and to form the desired shape. Forming of this type compound is difficult because it adheres to conventional tools and only remains workable for a few minutes.

A new forming technique in which a silicone rubber compound was applied to a surface and then formed with ice as a tool has been developed. This innovation should be useful in those industrial operations in which atmospheric-curing silicone rubber compounds are used to form either bonds or gaskets.

This technique can extend the time that a silicone rubber compound can be worked, and can eliminate adhesion between it and the ice. The water from the melting ice lubricates the compound, making it possible to apply and form a smooth surface.

Source: Kaye Schinbeckler, Julian E. Harris,
and James G. Ramsey, Jr., of
The Boeing Co.
under contract to
Kennedy Space Center
(KSC-10262)

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SEALING TECHNIQUE FOR A RECORDING PEN

The use of quick-drying ink for the high-speed operation of recording devices resulted in pen stoppages when the recorders were inoperative for a short period of time. To overcome this shortcoming, a technique was devised in which a polyethylene strip is inserted between the inking point and the chart paper to ensure an airtight seal for capillary-type pens. As a result of this arrangement, the pens remain in the "ready" condition for periods up to 48 hours, without pen stoppages.

Source: F. Holzler of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-13912)

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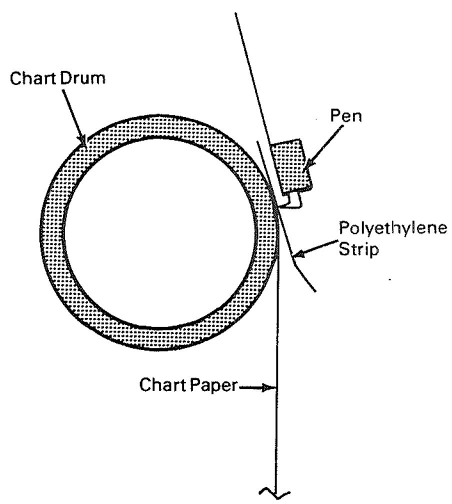
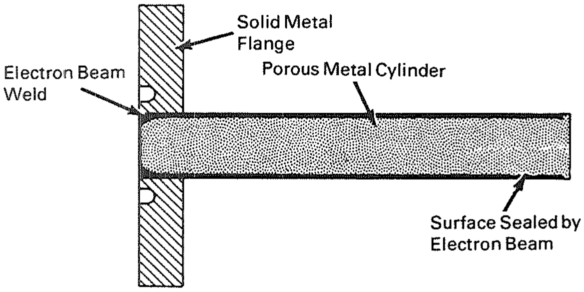


ELECTRON BEAM FOR SELECTIVELY SEALING POROUS METAL FILTERS

An electron-beam welding technique has been developed for selectively sealing the outer surfaces of porous metal filters and flow restrictors used in fluid flow systems. These items, used in liquid or gaseous systems, often require considerable length in proportion to diameter to provide adequate filtering or impedance. A typical configuration in which the fluid must flow through the entire length for maximum effectiveness is shown in the schematic. Since porosity in the cylinder surface would permit the fluid to follow a shorter path, the outer surface must be effectively sealed to force the fluid to flow the full length. This surface can be sealed by melting a thin outer layer of the porous material with an electron beam so that the melted material fills all surface pores. With the aid of beam deflection, the entire surface is scanned by the beam to form an impervious surface. The cylinder is then welded to a conventional flange of compatible material. The coating may be made as thin as one mil or up to 50 mils thick by varying electron beam power.



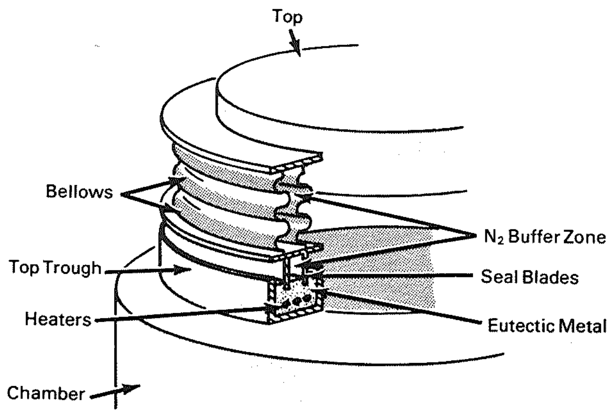
Source: John A. Snyder of
Hughes Aircraft Co.
under contract to
Lewis Research Center
and George Tulisiak
Lewis Research Center
(LEW-10162)

No further documentation is available.

TECHNIQUE FOR REMOTELY SEALING VACUUM CHAMBER BY EUTECTIC METAL

A technique in which a eutectic metal is used to remotely seal a vacuum chamber has been devised. Metal seal blades are inserted into a molten eutectic metal by pressurizing an expansion bellows. (The eutectic metal is an alloy of 45% lead with 55% bismuth having a melting temperature of 255°F.)

The vacuum chamber is provided with a trough in which a eutectic metal, together with electrical heaters to melt it, are placed. Seal blades are then attached to the bellows, which, in turn, are attached to the fixed top section. The chamber is remotely positioned directly under the top, and the seal blades are lowered into the molten metal by pressurizing the expansion bellows with nitrogen. Upon solidification of the eutectic metal, the seal is completed. To open the chamber, the metal seal is reheated and the bellows gas pressure removed (with a possible small amount of vacuum applied to the bellows to ensure retraction).



Source: R. Cordova and G. H. Sacoone of
Aerojet-General Corp.
under contract to
Space Nuclear Propulsion Office
(NUC-90091)

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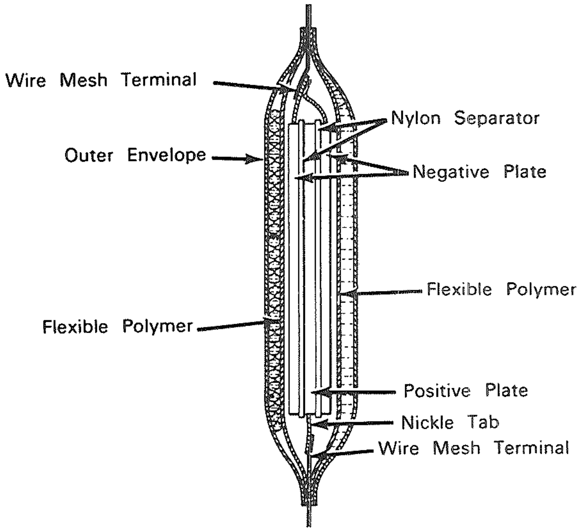
FRANGIBLE ELECTROCHEMICAL CELL AND SEALING TECHNIQUE

A flexible, compact electrochemical cell that is frangible under severe shock conditions has been constructed. Leak-tight integrity of the cell housing is maintained by polymer-to-polymer fusion bonds through holes in the expanded metal electrode terminals.

The cell includes a positive electrode plate between two negative electrode plates. The positive plate is impregnated with a nickel oxide active substance and the negative electrodes are impregnated with a cadmium active substance. Electrodes and separators are held in intimate electrical contact by nonconducting threads.

A thin-wall envelope of low water vapor and oxygen permeability is formed from two sheets of flexible polymeric material joined at their margins by bonding or adhesives to form a leak-tight seal around the electrodes and separators. An additional (outer) envelope may be formed from two more sheets of the same material making it possible to surround the inner thin-wall housing with either water or another high-heat capacity fluid to provide a thermal ballast for the cell.



Source: G. Halpert, J. Haynos, and J. Sherfey
Goddard Space Flight Center
(XGS-10010)

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